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Building Information Modelling for FM using IFC

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Abstract

Facility managers have to acquire, integrate, edit and update diverse facility information ranging from building elements & fabric data, operational costs, contract types, room allocation, logistics, maintenance, etc. With the advent of standardized Building Information Models (BIM) such as the Industry Foundation Classes (IFC) new opportunities are available for Facility Managers to manage their FM data. The usage of IFC supports data interoperability between different software systems including the use of operational data for facility management systems. Besides the re-use of building data, the Building Information Model can be used as an information framework for storing and retrieving FM related data. Currently several BIM driven FM systems are available including IFC compliant ones.

These systems have the potential to not only manage primary data more effectively but also to offer practical systems for detailed monitoring, and analysis of facility performance that can underpin innovative and more cost effective management of complex facilities.

Introduction

Facility managers have to ensure the functionality of the built environment (building including surrounding spaces) by integrating people, place, process and technology [FMA 2006]. Asset management, maintenance activities, property inspections, repairs, benchmarking, etc are all part of this profession. Obviously all these activities produce and need information such as the building description, room locations, people locations (movements), contracts (e.g. cleaning and maintenance), maintenance reports, performances, costs, etc.

Currently many software packages are available to support facility managers using this information. Widely available software packages such as Archibus (www.archibus.com), Facility Information Systems (www.fisinc.com), and FM:Systems (www.fmsystems.com) often link spatial data such as 2D drawings with databases offering functionality such as data management tasks, room planning, move management, cost analyses, document management, etc.

With the advent of Building Information Models the connection between geometry, semantics and database technology becomes more sophisticated. BIM contains more notions of objects in a building (including their geometry) and can therefore offer more functionality. A new generation of software systems is emerging using Building Information Models. This paper describes the concept of Building Information Models and analyses their potential advantage for Facility Management. In addition the first generation of BIM driven Facility Management tools are analyse

Building Information Models

Definition of a BIM

Simply put a building information model (BIM) is a database specifically for built facilities. BIM is an integrated digital description of a building and its site comprising objects, described by accurate 3D geometry, with attributes that define the detail description of the building part or element, and relationships to other objects, e.g. this duct is located in storey three of the building named Block B. BIM is called a rich model because all objects in it have properties and relationships, and based on this, useful information can be derived by queries, simulations or calculations using the model data. An example is the ability to support automated building code checking [Cheng, 2005] or a thermal load calculation. [Kam et al, 2003].

The principal difference between BIM and 2D CAD is that the latter describes a building by independent 2D views (drawings), e.g. plans, sections and elevations. Editing one of these views requires that all other views must be checked and updated if necessary, a clumsy and error prone process that is one of the major causes of poor documentation today. In addition, the data in these 2D drawings are graphical entities only, e.g. line, arc circle, etc. in contrast to the semantics of BIM models, where objects are defined in the terms of building parts and systems eg spaces, walls, beams, piles etc. A feature of BIM is that a 2D drawing can be 'generated' automatically from the model and one of many representation formats, such as visualisations and animations, schedules etc.

Generic Attributes of a BIM

The key generic attributes of a BIM are:

- *Robust geometry* - objects are described by faithful and accurate geometry, that is measurable
- *Comprehensive and extensible object properties* that expand the meaning of the object - any object in the model has some pre-defined properties. Objects thus potentially can be richly described e.g. a manufacturers' product code, or cost, or date of last service etc.
- *Semantic richness* - the model provides for many types of objects (walls, floors, beams, processes, etc) and relationships (is-contained-in, is-related-to, is-part-of etc) that can be accessed for analysis and simulation.
- *Integrated information* - the goal of the model is to hold all relevant information in a single repository ensuring consistency, accuracy and accessibility of data
- *Life cycle support* - the model definition supports data over the complete facility life cycle from conception to demolition, widening our currently restrictive over-emphasis on design and construction phase. For example client requirements data such as room areas or environmental performance can be compared with as designed, as-built or as-performing data, a valuable and pertinent function for asset and facility management.

Advantages of using BIM

Based on the attributes of a BIM, several advantages can be envisioned:

- *Consistency* in the data. Data is accurate and multiple versions of the same data are eliminated.

- *Intelligence in the model*. For example *windows* are automatically related to walls and cannot be located otherwise. A *switchboard* is part of a logical network of circuits, is geometrically described and is located spatially in a room on a storey of the building. Changing the height of a wall automatically updates relationships, quantities , etc.
- *Multiple representations* such as 2D drawings, 3D views, bills of quantities, logical connections (a building services system schematic)
- *Source of information for intelligent programs*. For example several CAD packages offer sunlight analysis, acoustic performance, sustainability.
- *Intelligent queries* such as how many steel beams are in the model longer than 2 meters, etc or which fire-rated doors have a current compliance certificate?.

Industry Foundation Classes

The Industry Foundation Classes (IFC) is a standardized Building Information Model based on an ISO standard (ISO, 1994) for sharing and accessing this data enabling interoperability between heterogenous software applications. Interoperability is defined as the seamless sharing of building data between multiple applications (or disciplines) over any or all life cycle phases of a building development project. The IFC is a standard (ISO PAS 16739) that is published by the International Alliance for Interoperability (IAI).

The IAI is a worldwide alliance of organisations in the construction industry - Architecture, Engineering, Construction and Facility Management (AEC/FM) - comprising 14 international chapters, from 21 countries with representation by over 550 businesses from private industry and government. The mission of the IAI is to integrate the AEC/FM industry by specifying a universal language that improves communication, productivity, delivery time, cost, and quality throughout the design, construction, operation and maintenance life cycle of buildings (*Figure 1*).

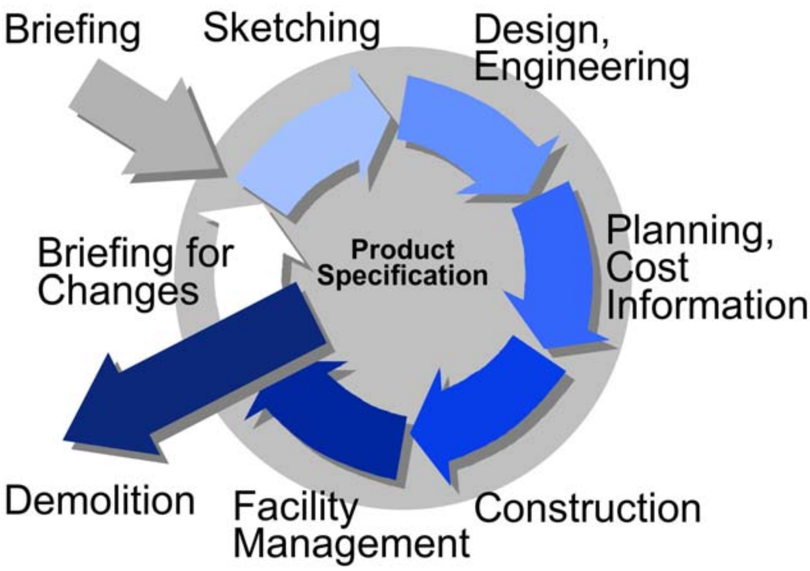

Figure 1 the focus of the IFC: supporting information sharing in the construction industry during all building phases. Source A Kiviniemi, VTT, Finland.

The focus on life-cycle has been a key aspect, as the current industry practice does not facilitate the efficient transfer of requirements, design and as-built construction data for the increasingly critical phases of operations and strategic asset & facility management.

The IFC Model Specification (Schema)

The scope of the IFC model can be understood as a series of layers in the model, each providing increasingly specialised functionality to support AEC/FM. These layers are distinguished as follows (see Figure 2 below):

- *resources* – fundamental concepts, generally taken from the STEP (ISO 10303) standard
- the *kernel* – concepts used globally in the model
- *extensions* – specialization of resources needed uniquely for AEC/FM domains
- *shared elements* – common concepts used by domains–functionally independent views (or disciplines) of the AEC/FM model.
- *domains* – the model, at its highest level specialises data for use in various discipline specific views eg Architecture, HVAC and for our purposes Facilities Management.

The core model is a rich description of the building elements and engineering systems that provides an integrated description for a building. This feature together with its geometry (for calculation and visualisation), relationships and property capabilities underpins its use as an asset and facility management database.

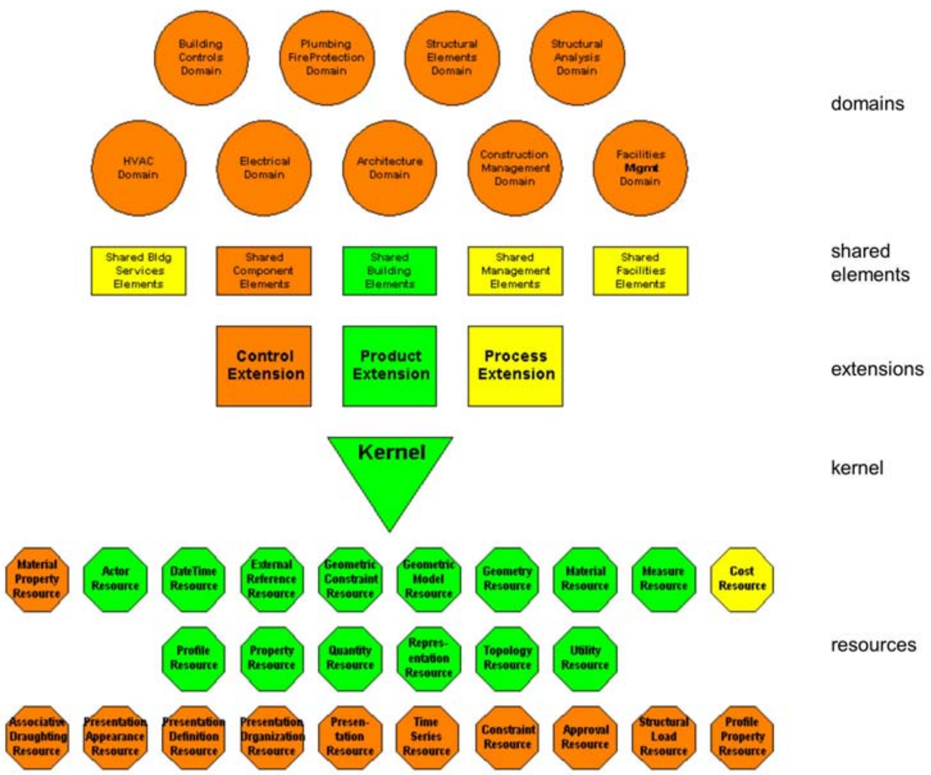

Figure 2: IFC 2x series Model.
Source: http://www.iai-international.org/Model/IFC(ifcXML)Specs.html

Advantages of Using IFC

IFC, a neutral standardized and industry supported data exchange mechanism for sharing Building Information Models, supports the interoperability between heterogenous software applications. Currently BIM models can be shared via the IFC between different CAD systems. In addition more applications are emerging which are IFC compliant such as construction and planning packages, building code checkers, etc.

Considering the systems that are widely in use today there are typically many separate applications, with their own data. This leads to many instances of the same data that are a source of incorrect, duplicating and thus redundant information. From the preliminary feedback of BIM projects (for example see [Kam C et al, 2003]) the usage of IFC makes building information more accessible, and improves the capacity to manage data over time.

The major advantages of using an open standard are:

- The information can be read and manipulated by any compliant software;
- Reduced user "lock in" to proprietary solutions. Third party software can be the "best of breed" to suit the process and scope at hand;
- Standardised BIM solutions consider the wider implications of information exchange outside the scope of any particular vendor;
- The information can be archived as ASCII files for archival purposes.

Data quality can be enhanced as the now single source of users' information has improved accuracy, correctness, currency, completeness and relevance.

Facility Management Submodels in IFC

The Facilities Management (FM) Domain is a key aspect of the IFC model, facilitating the currently poor connection after the completion of the design and construction phase with commissioning, operations and asset maintenance.

The *IfcSharedFacilitiesElements* Schema in the IFC model defines basic concepts in the facilities management domain. This schema, along with *IfcProcessExtension*, *IfcSharedMgmtElements* and *IfcFacilitiesMgmtDomain*, provide a set of submodels that can be used by applications needing shared information concerning facilities management related issues.

IfcSharedFacilitiesElements

The *IfcSharedFacilitiesElements* schema supports ideas including furniture, grouping of elements of system furniture into individual furniture items, asset identification, and inventory of objects (including asset, furniture and space objects within separate inventories). Figure 3 describes some entities in the *IfcSharedFacilitiesElements* schema.

- ***IfcActionRequest*** *is a request for an action to fulfil a need.*
- ***IfcCondition*** *determines the state or condition of an element at a particular point in time.*
- ***IfcConditionCriterion*** *is a particular measured or assessed criterion that contributes to the overall condition of an artefact.*
- ***IfcEquipmentStandard*** *is a standard for equipment allocation that can be assigned to persons within an organization.*
- ***IfcFurnitureStandard*** *is a standard for furniture allocation that can be assigned to persons within an organization.*

- ***IfcMove*** *is an activity that moves people, groups within an organization or complete organizations together with their associated furniture and equipment from one place to another. The objects to be moved, normally people, equipment, and furniture, are assigned by the IfcRelAssignsToProcess relationship.*
- ***IfcOrderAction*** *is the point at which requests for work are received and processed within an organization.*
- ***IfcPermit*** *A document that allows permission to carry out actions in places and on artefacts where security or other access restrictions apply*

Figure 3: Model entities within the IfcSharedFacilitiesElements

IfcFacilitiesMgmtDomain

The *IfcFacilitiesMgmtDomain* Schema defines basic concepts in the facilities management (FM) domain. The *IfcFacilitiesMgmtDomain* schema forms part of the Domain Layer of the IFC Model. It extends the ideas concerning facilities management outlined in the *IfcSharedFacilitiesElements* schema and management in general outlined in the *IfcSharedMgmtElements* schema. The objective is to capture information that supports specific business processes that are wholly within the domain of interest of the Facilities Manager. The aim is to provide support for information exchange and sharing within computer aided facilities management and computer aided maintenance management applications. The model extent will not support some of the more detailed ideas found in these applications.

The following are within the scope of this part of the specifications:

- *Managing the movement of people* and their associated equipment from one place to another. All types of move are considered to be within scope ranging from moving a single person from one office to another to the movement of complete organizations between locations.
- The *assignment of facilities management standards* according to roles played by actors within an organization. Assignment of standards is currently limited to space, furniture and equipment.
- Capturing information concerning the *condition of components and assets* both for subjective and objective assessment of condition.
- Recording the *assignment of permits* for access and carrying out work.
- Capturing *requests for action to be carried out* and the assignment of work orders to fulfil the needs expressed by requests.

Figure 4 describes some entities in the *IfcFacilitiesMgmtDomain*.

- **Error!*****IfcAsset*** *is a uniquely identifiable grouping of elements acting as a single entity that has a financial value*
- ***IfcFurnitureType*** *defines a particular type of item of furniture such as a table, desk, chair, filing cabinet etc.*
- ***IfcInventory*** *is a list of items within an enterprise*
- ***IfcOccupant*** *is a type of actor that defines the form of occupancy of a property.*
- ***IfcRelOccupiesSpaces*** *is a relationship class that further constrains the parent relationship IfcRelAssignsToActor to a relationship between occupants(IfcOccupant) and either a space (IfcSpace), a collection of spaces (IfcZone), a building storey (IfcBuildingStorey), or a building (IfcBuilding).*
- ***IfcServiceLife*** *is the period of time that an artefact (typically a product or asset) will last.*
- ***IfcServiceLifeFactor*** *captures the various factors that impact upon the expected service life of an artefact.*

- ***IfcSystemFurnitureElementType*** *defines a particular type of component or element of systems or modular furniture.*

Figure 4: Model entities within the IfcFacilitiesMgmtDomain domain

IfcSharedMgmtElements

The *IfcSharedMgmtElements* schema defines basic concepts that are common to management throughout the various stages of the building lifecycle. The primary classes in the schema are all subtypes of *IfcControl* and act to manage or regulate the conduct of the project in some way. This schema, along with *IfcProcessExtension* and *IfcConstructionMgmtDomain*, provide a set of models that can be used by applications needing to share information concerning management related issues. The objective of the *IfcSharedMgmtElements* schema is to capture information that supports the ordering of work and components, the development of cost schedules and the association of environmental impact information. The aim is to provide support for exchange and sharing of minimal information concerning the subjects in scope; the extent of the model will not support the more detailed ideas found in more specialized management applications. Figure 5 describes some entities of the *IfcSharedMgmtElements* domain.

- ***IfcCostItem*** *describes a cost or financial value together with descriptive information that describes its context in a form that enables it to be used within a cost schedule.*
- ***IfcCostSchedule*** *brings together instances of IfcCostItem either for the purpose of identifying purely cost information as in an estimate for constructions costs, bill of quantities etc. or for including cost information within another presentation form such as an order (of whatever type)*
- ***IfcProjectOrder*** *sets common properties for project orders issued in a construction or facilities management project.*

Figure 5: Model entities within the IfcSharedMgmtElements domain

Benefits of IFC Enabled FM

It is clear that the IFC model addresses many facility management processes, objects and relationships. The availability of high level objects in combination with the extensibility characteristics of the IFC model makes this a good starting framework for modelling FM related data.

In addition to the generic benefits of standardised BIM described above, the following FM specific advantages can be expected from this new integrated facilities management environment:

- *Faster and more effective processes* – information is more easily shared, can be value-added and reused;
- The IFC specification allows for any number of *user or project specific properties* according to a common format. This is one area where proprietary BIM solutions may constrain users. In some proprietary systems it is very difficult for an ordinary user to add additional properties;
- *Controlled whole life costs and environmental data* – environmental performance, maintenance and investment is predictable, life-cycle costs can be analysed and understood;
- *Better customer service* – information can be accessed in multiple formats appropriate to each user ie seating plans are understood through accurate visualisation;

- *Common operational picture* for current and strategic planning – as model data is inter-related developing scenarios and their impacts (such as budgeting for major maintenance, assessing security or understanding dislocation during construction activity) can be understood more easily leading to better decision making;
- *Visual decision-making* – allows executives, management and lay users (particularly) to understand the nature and relationships of the facility, eg building services failures through graphic 3D or abstract views generated from the model, etc;
- *Total ownership cost model* – all aspects of the facility including building usage and operations are in a single integrated repository.

Some user specific issues such as for example benchmark data are not yet addressed explicitly in the IFC, but user specific data can be attached to all IFC entities by the use of the IFC Property Set mechanism. In addition a link with (regular) documents is possible using *IfcDocumentReference* a reference to the location of a document. The reference is given by a system interpretable location attribute (e.g., an URL string) or by a human readable location, where the document can be found.

Commercial FM/AM IFC Compliant Software

A number of IFC based applications are commercially available for supporting AM/FM processes (this list is by no means exhaustive).

Vizelia

This product has been written from scratch based on the IFC standard, initially for one of France's largest insurance companies AXA, for local and international offices' facility management. Recently the product has been installed for the municipality of Luxembourg. The application has strong space management functions such as space occupancy rates, employee mobility, room planning but also asset management including preventive maintenance and tracking assets.

Ryhti

Olof Granlund (a Finnish Building Services consulting group, with a strong commitment to the BIM+IFC approach) has developed the RYHTI software for the management of buildings or entire building stocks. The RYHTI system is based on modules, enabling each organization to choose the appropriate package for its needs and purposes. All modules of the RYHTI software run on a common database, which creates the basis for an efficient management of information. The database contains information on the facilities, technical systems, equipment, people and documents. Due to the open structure of the database, the system can easily be adjusted to the individual needs of different organizations.

The following modules are available such as maintenance, planning and monitoring. Help desk, request management and monitoring, LTP (Long Term Planning), planning and monitoring of long term maintenance and refurbishment. Contract, management of service contracts, consumption, monitoring and reporting of energy and water consumption, document management and archiving of facility related drawings. Ryhti is a product which has created a loader to re-use IFC related geometry but does not directly support IFC FM objects.

Rambyg

Rambyg is a Danish system for operation and maintenance of buildings. It is meant to be used during the lifetime of a building. The system is web-based – all data is in one place and all data is accessible from any location with an internet connection. All the different actors use the system directly. Data is put into the system close to the source and those who need data get it directly from the system. The system is a standard system which has been sold for 4 years. IFC compatibility was recently added which has provided a new way for accessibility to rich data.

ActiveFacility

A Queensland based firm has developed an IFC server solution implemented in an Oracle database. ActiveFacility has created a new way of managing building data -a standardised model stores, updates and provides ready access to the extensive amount of information that relates to a building.

ActiveFacility’s services and software systems are built on the ISO - endorsed International Foundation Classes standards and are progressive tools for managing building information throughout the lifecycle of a building.

Key features of the product are:

- Creating an industry standard building model that encompasses all the information (architectural, mechanical, electrical, etc.) for an existing building.
- Making the unified building model accessible through the Internet so the information can be shared, analysed, queried and updated.
- Integrating the building model with other existing operational systems so all systems are continuously up-to-date.

Already FM systems compliant with IFC data are available though at present just a few. Most systems re-use IFC data and convert it into their own (native) format and storage environments. This enables re-use of the IFC data but is only a subset of the IFCs capabilities. The FM part of the IFC model is barely implemented, and as such offers a prospect for some innovative implementations.

Conclusions

The use of BIM offers many advantages for the FM industry particularly as an integrated data source which is model driven and provides data consistency. Such an integrated model is an ideal basis for more intelligence in the software and thus more functionality. The IFC model offers in this respect even more advantages as it addresses the importance of interoperability between heterogenous software systems.

From a software point of view it is fair to say that this is the first generation of IFC compliant FM systems. Current software systems are not yet as mature as the long-time available 2D based FM implementations or existing FM systems that have developed IFC imports to re-use (some) geometry related data. This means that only part of the IFC model is being re-used and therefore not all functionality of FM BIM is currently exploited.

It is expected that by choosing IFCs as the main data format will allow greater commercial software application options, long term use of a single open data repository and flexibility to adapt as the standard and compliant applications implement more sophisticated and better functioning systems.

In summary, these systems have the potential to not only manage primary data more effectively but also to offer practical systems for detailed monitoring, and analysis of facility performance that can underpin innovative and more cost effective management of complex facilities.

Credits

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